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EVALUATION AND HARMONIZATION OF RULES AND GUIDANCE ON THE DISCHARGE OF DISCHARGE WATER FROM EGCS INTO THE AQUATIC ENVIRONMENT, INCLUDING CONDITIONS AND AREAS

Substances contained in discharge water from exhaust gas cleaning systems

Submitted by Norway

SUMMARY

Executive summary:	This document considers the origin of the substances detected in the samples from discharge water.
Strategic direction, if applicable:	1
Output:	1.23
Action to be taken:	Paragraph 27
Related documents:	MEPC 78/93; MEPC 79/5/1; MEPC 82/5/1, MEPC 82/INF.22; PPR 11/7/5; PPR 12/7/1 and PPR 12/INF.11

Background

1 In document PPR 12/7/1, Norway provided relevant data to be used for the development of representative emission factors of discharge water from EGCS. This document considers the origin of the substances detected in the samples from discharge water in order to provide a better understanding of the data presented on discharge water from EGCS.

2 Norway's understanding is that the substances detected in the discharge water from EGCS can come from:

.1 the scrubbing process itself where substances present in the fuel oil or resulting from (incomplete) combustion of the fuel are contained in the discharge water;

.2 the ship's seawater system;

.3 the ambient water due to pollution or from naturally occurring metals in seawater; and

.4 the anti-fouling and anti-corrosion system on the ship's hull.

Ship's seawater system

3 A ship's seawater system is crucial for the operation of various onboard systems that rely on seawater such as engine and cargo cooling, air conditioning, firefighting, ballast control and exhaust gas cleaning if the ship is equipped with such a system. As the seawater passes through the ship's seawater system, the composition of the seawater will be altered on its path. The design cooling water flow is based on tropical conditions (32°C), and with lower seawater temperatures the flow may be reduced if the ship is equipped with cooling water flow control.

4 Sea chest: The seawater enters the ship through the sea chest which is covered by antifouling and has several anodes for corrosion protection. On the ships in the Solvang fleet, typically 20 kg to 40 kg of aluminium with a five-year lifespan is used. The aluminium anode loss rate is depending on the coating condition and not on whether the ship has a scrubber or not. From the sea chest, the water goes through a strainer where marine growth protection is added.

5 Strainer: In shipping, there are four main types of Marine Growth Protection System (MGP-system) used in the seawater system: electrolytic system, chemical dosing, ultrasonic system and electro-chlorination. All ships in this study have the electrolytic system where copper and aluminium anodes are used together with electricity to create copper ions, as illustrated in figure 1 below. The size of anodes is given by the maximum flow of the strainers (kg/year), and the lifespan design is three years.

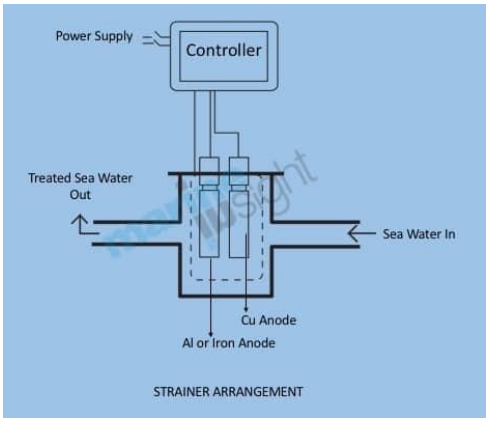

Figure 1: The diagram demonstrates the typical set-up using an electrolytic system for preventing marine growth within the ship's seawater system. Source: Marine Insight

6 As the seawater passes through the electrolytic MGP-system, copper and aluminium will be added to the seawater, depending on the design and flow rate. The release of copper and aluminium in this system is based on the water flow design capacity and not the actual flow through the system. However, the standard system has two settings, eighter full flow or idling. To illustrate how much copper and aluminium will be released from a ship with or without an EGCS, an example from two sister ships in the Solvang fleet is given. Both ships are large gas carriers (LGC), one with an EGCS and one without:

.1 LGC without an EGCS:

.1 Seawater to be treated: 1900 m^3/h from either of two strainers:

.1 Copper (Cu): 99.8 kg (2 ppb x 1900 m^3/h x 3 years x 24 hours x 365 days x 10^{-6});

.2 Aluminium (Al): 25 kg (0.5 ppb x 1900 m^3/h x 3 years x 24 hours x 365 days x 10^{-6}); and

.3 Annual release would be about 33 kg copper and 8 kg aluminium.

.2 LGC with an EGCS (three of the ships in this data):

.1 Seawater to be treated: 2200 m^3/h from either of two strainers:

.1 Copper (Cu): 116 kg (2 ppb x 2200 m^3/h x 3 years x 24 hours x 365 days x 10-6);

.2 Aluminium (Al): 29 kg (0.5 ppb x 2200 m^3/h x 3 years x 24 hours x 365 days x 10^{-6}); and

.3 Annual release would be about 39 kg Cu and 9 kg Al.

7 The example above illustrates that a ship with a scrubber, in theory, could release about 15% more copper and aluminium per year than the same ship without a scrubber system. The figure for a given ship will depend on the actual increase in design seawater flow rate compared to a ship without an EGCS. Theoretically, the system gives a fixed anode loss in gram per day independent of actual flow, thus low flow will give high concentration and vice versa. This fact, together with the flow dynamics inside the strainers, explains the large variations in the copper concentration in the inlet water samples.

8 In general, a seawater system does not work at full capacity and by introducing a "smart" control system for the MGP-system it would be possible to reduce the copper and aluminium release by 70% to 80%, i.e. reducing the copper release down to 2 µg/l as per design.

9 An example of "strange" readings and a non-representative sample of intake seawater is shown in figure 2 below. The ship has copper and aluminium electrodes in the MGP-system and aluminium electrodes as corrosion protection. Zinc is not used as a corrosion protection on this ship.

10 On 30 August 2024, **Clipper Enyo** was ready to take water samples from the EGCS and deliver them to the laboratory for analysis. The ship had been idling outside Houston for a month, with low water flow through the strainer. Even though the engine load and water flow had been stable for hours prior to sampling, the zinc, copper and lead had accumulated in the top of the seawater strainer. Measurements of the inlet water showed concentrations of 2020 µg/l of zinc, 299 µg/l of copper, and 590 µg/l of lead, indicating that these elements had not been flushed out. After five hours, the level of these elements was drastically reduced, but still elevated and not representative for the actual flow.

11 It is reasonable to believe that the copper originates from the anodes, where small copper particles are trapped on the inside of the filter mesh, where also larger particles from the seawater are trapped. Norway's understanding is that the particles trapped inside the strainer might be contaminated by lead and zinc, and it takes many hours to stabilize the levels in the seawater system. This seems like a reasonable explanation due to the extensive industrial activity in the Houston region, including petrochemical production, with the result that the waters and sediments in the area contain elevated levels of different heavy metals.

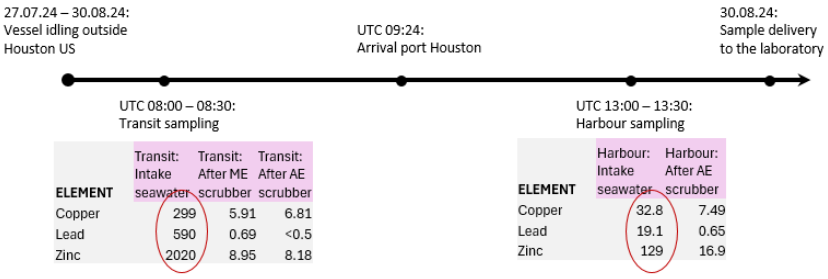

Figure 2: Timeline of the ship Clipper Enyo with elevated concentrations in the inlet water of copper, lead and zinc after idling a month outside Houston.

Substances contained in EGCS discharge water and their origin

12 As described above, the discharge water will contain substances from the scrubbing process, from substances in the ship's seawater system and from substances present in the ambient water. It is also possible that substances come from the ships anti-corrosion and antifouling systems on the ship's hull. However, the release from a ship's hull will be the same for ships with or without an EGCS and is not related to the use of the EGCS.

13 Table 1 below is reproduced from the Report of the GESAMP Task Team on exhaust gas cleaning systems (PPR 7/INF.23) and provides a useful reference when it comes to substances present in the ambient seawater. It should be noted that different ports will have different substances present in different concentrations, depending on historical industrial activities in the ports.

Table 1. Total trace metal concentrations (µg/l) reported in different areas. From document PPR 7/INF.23

[µg L_{-1}]	World Open Ocean			World Coastal waters		Australia Harbour 1		Australia Harbour 2		Mao Minorca Harbour	
Element	**min**	**max**	**average**	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**
V	1.5	2.0	1.5	-	-	3	8				
Fe	0.001	0.1	0.03	-	-	180	350	8	530	0.07	1.9
Ni	0.1	0.7	0.5	0.9	2.1	0.3	1.9	BDL	9	0.16	0.35
Pb	<0.002	0.03	0.02	1.0	1.5	0.4	55	1	7	0.04	0.5
Zn	0.003	0.6	0.3	12	22	14	67	1	35	0.1	3.9
Cd	<0.001	0.1	0.06	-	-	0.1	0.8	1	7	0.01	0.04
Hg	<0.002	-	0.0004	-	-	-	-	BDL	BDL		
As	1.5	1.9	1.7	0.8	1.5	3.2	8.2	2	8		
Cr	0.2	0.3	0.2	-	-	0.4	1.3	1	2		
Cu	0.03	0.3	0.3	0.9	1.9	0.9	350	1	40	0.1	3.4
Mn	0.004	0.27	0.02	1.1	6.0	6.5	160	1	51		
Al	0.01	1.1	0.5	-	-	-	-	1	1200		
Co	<0.0006	0.001	0.001	-	-	2.2	5	1	2	0.01	0.04
Mo	-	-	10	-	-	-	-	6	13	9.1	14
Ag	<0.001	0.004	0.002	-	-	-	-	BDL	1		
Se	0.04	0.2	0.1	-	-	-	-	1	5		

14 As described in document PPR 12/7/1, all the samples that have been analysed and presented come from ships using residual fuels category RMG-380 according to ISO 8217-2024. These are high sulphur fuel oils (HSFO), having a sulphur content above 0.50% by mass. Ships without an EGCS are expected to use very low sulphur fuel oil outside ECAs (VLFSO, RME 180-0.5 or RMG 380-0.5), a residual fuel with a sulphur content of 0.50% by mass. Inside ECAs, ships without EGCS are expected to use ultra-low sulphur

fuel oil (ULFSO, RME 180-0.1 or RMG 380-0.1), a residual fuel with a maximum sulphur content of 0.10% by mass, or a distillate marine fuel with a maximum sulphur content of 0.10% by mass.

Table 1. Measurement of the amounts of heavy metals contained in heavy fuel oil for ships.*

		Unit	HSFO 1	HSFO 2	HS HFO（10samples）
Basic Properties	Viscosity	cSt@50°C	278	299	87 ~ 276
	Carbon	% m/m	88.1	85.7	86.6 ~ 87.3
	Hydrogen	% m/m	11.3	11.3	10.3 ~ 12.4
	Nitrogen	% m/m	0.4	0.4	0.09 ~ 0.22
	Sulphur	% m/m	2.6	2.9	0.28 ~ 2.49
Heavy metals	Vanadium	mg/kg	122	121	44 ~ 63
	Nickel	mg/kg	23	22	16 ~ 23
	Iron	mg/kg	16	16	3 ~ 17
	Zink	mg/kg	1	< 1	0 ~ 3
	Lead	mg/kg	< 1	< 1	0
	Copper	mg/kg	< 1	< 1	—
	Cadmium	mg/kg	< 1	< 1	—
	Chromium	mg/kg	< 1	< 1	—
	Arsenic	mg/kg	< 0.5	1	—

15 Paragraphs 16 to 26 below consider the origin of some of the substance in more detail. The concentrations of the relevant substances noted below refer to document PPR 12/7/1 and the data presented therein.

16 Arsenic (As) was detected in all samples. The delta average ($\Delta_{average}$) is around zero which indicates that the scrubber process itself does not contribute to the As detected in the discharge water. According to the dataset, the concentration of As varies depending on physical location. There are differences between harbour (~3.4 µg/l) and transit (~3.1 µg/l). As can be seen in the tables above, As can also be found in small concentrations in seawater and in residual fuel oils.

17 Barium (Ba) is detected in all samples. In transit, $\Delta_{average}$ is close to zero (0.09 µg/l), which indicates that the scrubber process itself does not contribute to the Ba detected in the discharge water. There are also significant differences between harbour (~20 µg/l) and during transit (~10 µg/l) measurements. Though not indicated in table 2 above, Ba is also found in seawater in different concentration depending on depth and location (~5 to 20 µg/l).

18 Cadmium (Cd) is detected in less than 50% of the sample. $\Delta_{average}$ is zero which indicates that the scrubber process itself does not contribute to the Cd found in the discharge water (0.03 µg/l). Cd is used in corrosion protection on steel, so trace amounts can come from parts in the scrubber itself, but the data do not support this. As can be seen in the tables above, Cd can also be found in very small concentrations in seawater and in residual fuel oils.

19 Chromium (Cr) was detected in about 50% of inlet samples and around 80% to 90% after scrubber samples. According to the dataset, the concentration of Cr varies depending on physical location, indicating that the substance is a pollutant in the ambient water. $\Delta_{average}$ is around 1 to 3.5 µg/l which indicates that the scrubbing process or system itself contribute to the Cr detected in the discharge water. Cr is an important component in the making of stainless steel, and since the scrubber itself is made of stainless steel, it is very likely that some of the Cr is coming from the scrubber body. As can be seen in tables 1 and 2 above, Cr can also be found in very small concentrations in seawater and in residual fuel oils.

* The table is taken from the Report by the expert board for the environmental impact assessment of discharge water from scrubbers (Japan) https://www.mlit.go.jp/common/001327168.pdf

20 Copper (Cu) was detected in nearly all samples. In harbour, the concentration was measured to ~9 µg/l in and out, and in transit ~7 µg/l. This difference can be explained by reduced waterflow in port. $\Delta_{average}$ is around zero which indicates that the scrubbing process itself does not contribute to the Cu detected in the discharge water. As discussed above, the MGP-system is the main contributor to the Cu found in the discharge water, and the concentration varies in time and space, and changes in flow produce large variations in Cu levels. As can be seen in tables 1 and 2 above, Cu can also be found in very small concentrations in seawater and in residual fuel oils.

21 Lead (Pb) was detected in less than 50% of the samples. The average concentration is 0.25 to 0.6 µg/l, and $\Delta_{average}$ is around zero, which indicates that the scrubber process does not contribute to the Pb detected in the discharge water. As can be seen in tables 1 and 2 above, lead can be found in very small concentrations in seawater and in residual fuel oils.

22 Mercury (Hg) is only detected in 2 of 223 samples and the net value is zero. As can be seen in tables 1 and 2 above, Hg can be found in very small concentrations in seawater.

23 Nickel (Ni) was detected in nearly all samples and the concentration of inlet water in harbour is slightly higher than in transit. $\Delta_{average}$ varies from 28 to 50 µg/l, which indicates that the scrubber process is the main contributor to the Ni in the discharge water since Ni is present in a significant amount in residual fuel oils. Ni is also an important component in stainless steel production. As can be seen in tables 1 and 2 above, Ni can also be found in very small concentrations in seawater.

24 Vanadium (V) was detected in all samples with concentration from 2.2 µg/l to 2.6 µg/l in inlet water, and 117 µg/l to 148 µg/l in discharge water. $\Delta_{average}$ shows that the scrubber process is the main contributor to the V in the discharge water since V is present in significant amount in residual fuel oils. V is also used in steel alloys. Though not indicated in table 2 above, V can be found in seawater in different concentrations (~1 to 2 µg/l).

25 Zinc (Zn) was detected in ~75% of all samples and the concentration was measured to ~10 µg/l in both inlet water and discharge water. $\Delta_{average}$ is around zero which indicates that the scrubber process itself does not contribute to the Zn detected in the discharge water. Zn can be found in variable concentrations depending on location, as illustrated in table 1 above, and, in addition, a small amount can also be present in residual fuel oils. The ships in this study are not using zinc for corrosion protection, but aluminium.

26 Polycyclic aromatic hydrocarbon (PAH) is a group of persistent organic compounds that are emitted or discharged during the incomplete combustion of fuel oil, including lubricants. Engine design, maintenance and operation profile would affect the combustion process and the amount of PAH emitted or discharged. In the inlet water, most of the samples are below the detection limit, so the PAHs detected in the discharge water come from the scrubbing process. Sum PAH was 2.29 µg/l in harbour. In transit, the sum of PAH after auxiliary engine scrubber was 5.79 µg/l, and after main engine scrubber 5.75 µg/l.

Action requested of the Sub-Committee

27 The Sub-Committee is invited to consider the information contained in this document and take action as appropriate.